OSTRACODS, LAND PLANTS, AND CHARALES FROM THE BASAL PURBECK BEDS OF PORTESHAM QUARRY, DORSET

by D. BARKER, C. E. BROWN, S. C. BUGG *and* J. COSTIN

ABSTRACT. A thin cherty layer near the base of the Purbeck Beds in Dorset has yielded a flora of land plants (including stems of *Equisetum mobergii*, isolated seeds referred to *Carpolithes rubeola*, *C. glans*, *C. rhabdotus*, *C. cocos*, *C. gibbus*, *C. acinus*, and *C. westi* spp. nov., and cones of *Araucarites sizerae* sp. nov.) and freshwater Charales (*Clavator westi* sp. nov.) as well as freshwater ostracods. The discovery of *Clavator westi* in Lower Purbeck deposits opens up the possibility of separating the Lower Purbeck from the Middle Purbeck using the Charales. Among the ostracods *Cypridea dunkeri* Jones is shown to have stratigraphical value. Correlation of these basal Purbeck Beds in Dorset with the Swindon Series further north indicates that at Swindon either Purbeck conditions were established earlier than in Dorset, or that Portland conditions recurred later.

THE basal Purbeck Beds are famous for their preservation of a fossil forest with 'tufaceous envelopes', 'dirt beds' with the remains of cycads, ostracod limestones, fossil insects, and freshwater limestones crowded with gastropods. Thus we have a vivid picture of a luxuriant coastal swamp, thickly forested and teeming with life. This paper shows how an examination of the fossils in a quarry in Dorset (map ref. SY 611859) can add to this broad picture. The basal Purbeck Beds are not wholly freshwater. They record cycles, ranging from freshwater to super-saline. This is borne out by text-fig. 1 in which West has kindly provided a graph of relative palaeosalinity based on a detailed petrological study of the section (see West 1975).

The basal Purbeck Beds of Dorset include the Dirt Beds, which are thought to be fossil soils. The soils usually consist of dark calcareous shale with numerous carbonaceous wood fragments and in which fossil coniferous trees are often found (Woodward 1895; Strahan 1898). The most westerly exposure of these Dirt Beds is to be found in an ancient quarry (map. ref. SY 611859) at Portesham in Dorset. The quarry is well known for a 15-ft long tufa-coated tree trunk which was believed to be a fossil elephant. The section exposed is shown in text-fig. 1 and commences in the Portland Beds. These are massive limestones with large marine lamellibranchs which grade upwards to poorly fossiliferous, thinly bedded limestones of the Purbeck. Thus a facies change occurs between the Portland and Purbeck beds which is transitional; the limestones become laminated, there is an increasing abundance of ostracods, and the large marine bivalve molluscs disappear.

In 1961 West reported that Charales and other well-preserved freshwater fossils such as ostracods had been found in chert from one of the Dirt Beds in this small quarry. Subsequently the material was sent to the University of Reading, where Professor Harris supervised the work of Misses Brown, Bugg, and Costin. The ostracods in the section are described separately by Barker. The chert lies in hollows on the eroded surface of rounded, slightly distorted, limestone pebbles. It is a white-weathering rock, rather friable with pseudomorphs after gypsum often separated
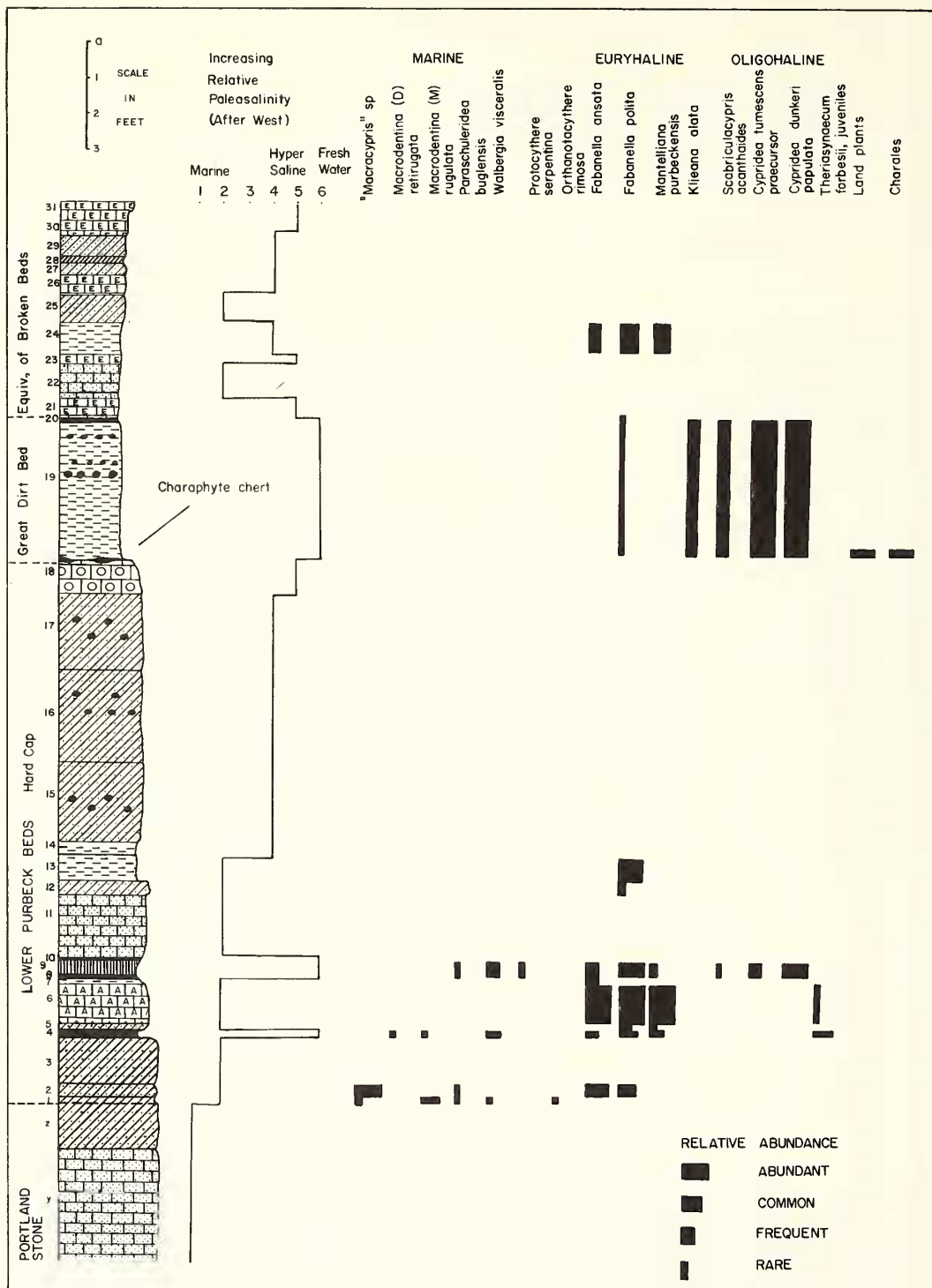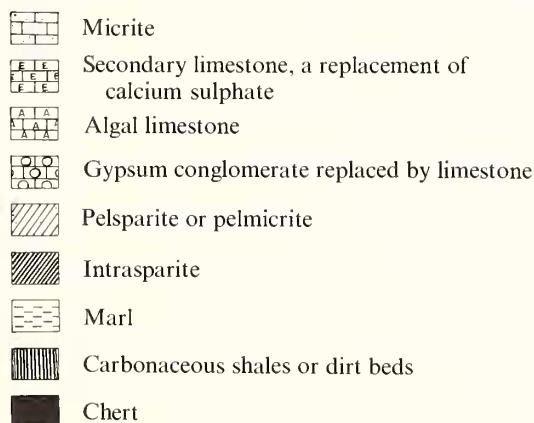
by marl. According to West (1975) it is surprising to find the remains of freshwater fossils together with evidence of evaporites in the same bed. In this, the Charophyte Chert of West (1961), siliceous replacements of Charales, freshwater ostracods, and gastropods are to be found in association with silicified and carbonaceous plant remains. The chert easily disintegrates with the addition of dilute hydrochloric acid.

West 1975 suggests that the formation of the Charophyte Chert required dramatic changes in palaeosalinity during its formation. He also suggests there is evidence for fluctuation in the depth of water. Hence one can envisage coastal lagoons, similar to those in South Australia, which are fresh or brackish during the winter with abundant water-plants and molluscs, and in the summer high temperatures produce evaporites. Charales are normally freshwater but can tolerate salinities up to $10^0/_{00}$ (Groves and Bullock-Webster 1924). Carbonaceous dirt beds with plant remains probably originated as marshy soils. The famous 'Mammal Bed' of Durlston Bay is similar and contains freshwater molluscs (Arkell 1941). Thus the Dirt Beds probably indicate sub-aerial exposure. Fragments of Charales are by far the most common plant fossils in the Charophyte Chert, representing a whole suite of organs, stems, vegetative leaves, reproductive leaves, oogonia, and gyrogonites, all of which probably belong to a single *Clavator* species. The land plants are the first to be described from the British Purbeck since *Cycadeoidea gigantea* Seward, 1897.

## STRATIGRAPHICAL AND PALAEOGEOGRAPHICAL CONCLUSIONS

A comparison of the Portesham section with sections of similar age at Swindon (Wiltshire) and Aylesbury (Buckinghamshire) has been made. At Swindon the fresh-water beds alternate with marine limestones of Portland facies. An analysis of the ostracods showed that these beds are correctly correlated with the basal Purbeck

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TEXT-FIG. 1. Vertical section of part of the Portesham Quarry exposure, including most of the Lower Purbeck Caps and part of the Portland Stone. The construction of the Palaeosalinity Curve is based on petrographical evidence provided by West, though West (1975) has since made minor revisions. Six groups of faunal and mineralogical features have been used as indices of Paleosalinity from fresh or slightly brackish to evaporitic conditions. The petrographical rock types are represented as follows:

Micrite

Secondary limestone, a replacement of
    calcium sulphate

Algal limestone

Gypsum conglomerate replaced by limestone

Pelsparite or pelmicrite

Intrasparite

Marl

Carbonaceous shales or dirt beds

Chert

Beds and Upper Portland Beds but not with the Middle Purbeck as before seemed possible (Barker 1966). It seems unlikely that the transition from Portland Beds to Purbeck Beds was synchronous in England. The presence of *C. dunkeri papulata* suggests that the Purbeck Beds of Swindon can be correlated with the basal Purbeck Beds of Dorset. As Purbeck Beds at Swindon interdigitate with marine beds of Portland facies, we must conclude that the basal Purbeck Beds in some places were being laid down at the same time as the upper Portland Beds in others. Thus the basal Purbeck Beds are alternative facies of the upper Portland Beds in England.

There are two possibilities (text-fig. 2), firstly the Purbeck intercalation (*x* in text-fig. 2*a*) below the Portland facies (*y* in text-fig. 2*a*) represents a terrestrial influence
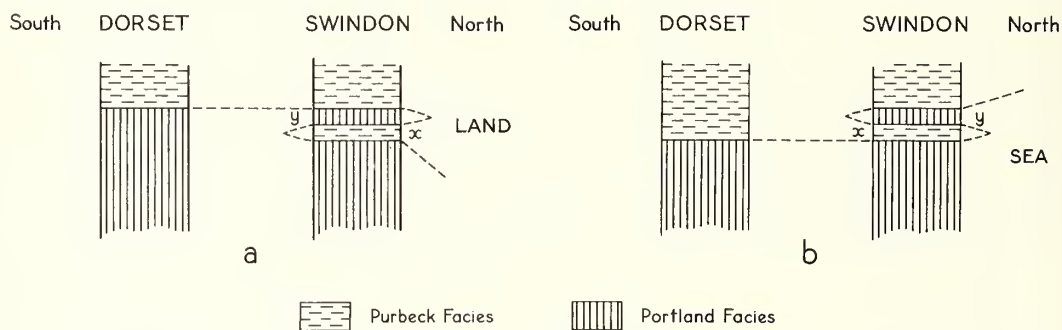
TEXT-FIG. 2. Diagram to illustrate the two interpretations of the interdigitation of the Purbeck Beds with the Portland Beds at Swindon (see text for explanation).

from a northerly landmass. The Purbeck intercalation at Swindon would therefore be older than the earliest Purbeck Beds in Dorset. The second possibility is that the intercalation of the Portland facies (*y* in text-fig. 2*b*) represents a later marine incursion from a northerly lying sea. If the latter alternative were true, the Portland Beds of Swindon should have a more complete fauna than those of Dorset. In fact they are less complete since no ammonites of the uppermost zone (*Titanites giganteus*) are known, though the Swindon Roach may well be of this age.

In addition to the ostracod and ammonite evidence an additional item sheds further light on the Portland–Purbeck transition. Amongst the silicified fossils recovered from the Charophyte Chert was a single tooth of a *Trigonia*. According to Dr. L. R. Cox it matches the teeth of *Trigonia* so abundant in the Portland 'Roach' of Portland Island (*Laevitrigonia gibbosa*). This indicates that in Charophyte Chert times, the topmost Portland Beds were being eroded not far away from Dorset. This erosion must have taken place before the shells of the Roach had been dissolved away to leave the vacuolar limestone that is now such a familiar feature at this horizon.

THE OSTRACODS (D. B.)

The most abundant ostracod in the Charophyte Chert of Portesham Quarry was identified by West (1961) as *Ulwellia papulata* Anderson, and it was claimed by him as evidence for correlating the Swindon Series with these lowermost Purbeck Beds of Dorset. Earlier Arkell and Sylvester-Bradley (1942) had discussed the age of the Swindon Purbeck Beds and came to no definite conclusions, though Arkell favoured a Middle Purbeck age and Sylvester-Bradley a Lower Purbeck or Portlandian age.

In addition to *Cypridea dunkeri papulata* fourteen species of ostracod have been recognized from the Purbeck Beds shown in text-fig. 1. These can be divided into three groups on the basis of salinity preference: (see text-fig. 1; for systematics see Barker 1966*a*, *b*).

(*a*) Marine including '*Macrocypris*' sp., *Macrodentina* (*D*) *retirugata*, *M.* (*D*) *rugulata*, *Paraschuleridea buglensis*, *Wolbergia visceralis*, *Protocythere serpentina*, and *Orthonotacythere rimosa*.

(*b*) Euryhaline (brackish to hypersaline) with *Fabanella ansata*, *F. polita*, and *Mantelliana purbeckensis*.

(*c*) Oligohaline with *Klieana alata*, *Scabriculocypris acanthoides*, *Cypridea tumescens praecursor*, *Cypridea dunkeri papulata*, and *Theriosynoecum forbesii*.

All the beds of the section ascribed to the Purbeck (i.e. all except Beds y and z) were searched for ostracods, but none were found in those not listed. Euryhaline forms were found in all beds containing ostracods except Bed 1, in which only marine forms occur, and Bed 19 (the Charophyte Chert) in which *C. dunkeri papulata* was the only species found. Beds 4 and 8 are interesting in that they show a mixture of oligohaline, euryhaline, and marine forms. These are 'dirt beds', and contain pebbles of the pene-contemporaneous marine Portland Beds. The marine ostracods in them are therefore likely to have been derived.

THE CHARALES (J. C.)

Fragments of Charales are the commonest plant fossils in the Charophyte Chert. Some 20 kg of the Cherty Limestone was treated with hydrochloric acid and yielded secondarily silicified rock pieces of various sizes and also some hundred grams of sand. Charalean fragments occur with moderate frequency in this sand, at between ten and a hundred per gram. The fragments are small and study of the surface of large cherty lumps, where the silicified fossils project on its surface, shows that even these charalean remains are in small pieces. Evidently the original calcified material was broken up before it was finally deposited, though no doubt further damage happened when the fossils were extracted. Many were very fragile.

The fossils represent a whole suite of organs, stems, vegetative leaves, reproductive leaves, oogonia, and gyrogonites which could well belong to a single *Clavator* species and they are so regarded here. As, however, the fragments are small, the evidence of continuity between the different parts is not as complete as it was for *C. reidi*. It proved impossible to fit the specimens into one of the three species described by Harris (1939) without modifying the concept of those species and accordingly a new species is described, using Harris's descriptive terms.

Apart from very slight traces of a cutinized membrane in the oogonium, the fossils represent the calcified parts alone. There are specimens in the limestone which have escaped secondary silicification but these were not studied. I have assumed that in

the silicified specimens the silicification does full justice to the original calcification, and that apparent defects are due to original slight calcification. Sometimes the hollow fossils have been filled up with silica, making them solid.

SYSTEMATIC DESCRIPTIONS

CHAROPHYTA (CHARALES)

Family CLAVATORACEAE Harris, 1939
Genus CLAVATOR Reid and Groves, 1916 emend. Harris, 1939
Clavator westi sp. nov.

Plate 57, figs. 1–10

Diagnosis. Internodes normally attaining a diameter of 0·6 mm, nodes of 1·2 mm. Leaves up to 0·4 mm thick. Calcified parts of spine cells covering leaves and stem, short and weakly developed; often missing on internodes.

Utricle of oogonium weakly developed, sometimes absent; rarely concealing more than two-thirds of oogonial surface. Oogonium ovoid with broad apical beak (which is easily broken). Length with beak about 650 μm, most common length (with partly broken beak) about 600 μm. Breadth about 450 μm, extremes 370 μm and 550 μm. Surface shows large flattened tubercles. Gyrogonite of oogonium ovoid and beaked, typically 385 μm broad and 545 μm long including the apical beak. Length of apical beak 45–75 μm. Gyrogonite lateral view crossed by 6, 7, or 8 spiral cell ridges.

Holotype. British Museum V.44893. Figured on Plate 57, fig. 5. *Material.* British Museum V.44883–44905.

Description. The stem internodes are only fragments ranging in width from 0·4 to 0·8 mm. The length is unknown but may be 1 cm. The internode has a central tube surrounded by twelve cortical tubes which may be inclined spirally. The coating of spine cells is incomplete, so the cortical tubes are clearly seen. Where there are no spine cells preserved, the short cells of the cortical tubes have a hole in their calcified surface where an uncalcified spine cell may have arisen. A well-developed spine cell is surrounded by 6–8 small cells and these by an outer circle of small cells making a rosette of about 20 cells.

The nodes are about twice as broad as the internode. The swelling below is gradual but the contraction above is sudden. Each node has the stumps of six leaves. One shows a small branch stem and at its side a 'nodal hole'. This branch has a sheath of small spine cells. The swelling of the node is caused by the enlargement of six of the cortical tubes and these bear the leaves. The other six cortical tubes diminish and disappear below the leaves. Most nodes have no calcified spine cells but one has a well-developed crust of them. In all these and some other details the node agrees with that of *Clavator reidi* Harris.

EXPLANATION OF PLATE 57

Clavator westi sp. nov.

Fig. 1. Node seen from above showing six leaf bases. V.44898, ×4·5.

Fig. 2. Antheridial leaf. The antheridial holes are in the centre of spine cell rosettes. V.44900, ×4·5.

Fig. 3. Stem internode with longitudinal cortical cells showing small uncalcified regions where it is presumed spine cell rosettes were attached. V.44899, ×4·5.

Fig. 4. Oogonium showing the apical beak and more or less clear traces of nine utricle cells, three of which project basally. V.44888, ×75.

Fig. 5. An unusually well-preserved oogonium still attached to a leaf. V.44893, ×45.

Fig. 6. Node with peculiar spine cells around the leaf bases. V.44905, ×2·5.

Fig. 7. Gyrogonite. V.44892, ×70.

Fig. 8. Stem internode with unusually well-developed spine cells covering the cortical cells. British Museum V.44894, ×4·5.

Fig. 9. Typical stem internode. V.44902, ×4·5.

Fig. 10. Stem internode. The cortical cells are spirally inclined and the spine cell rosettes are well preserved. V.44901, ×4·5.

PLATE 57
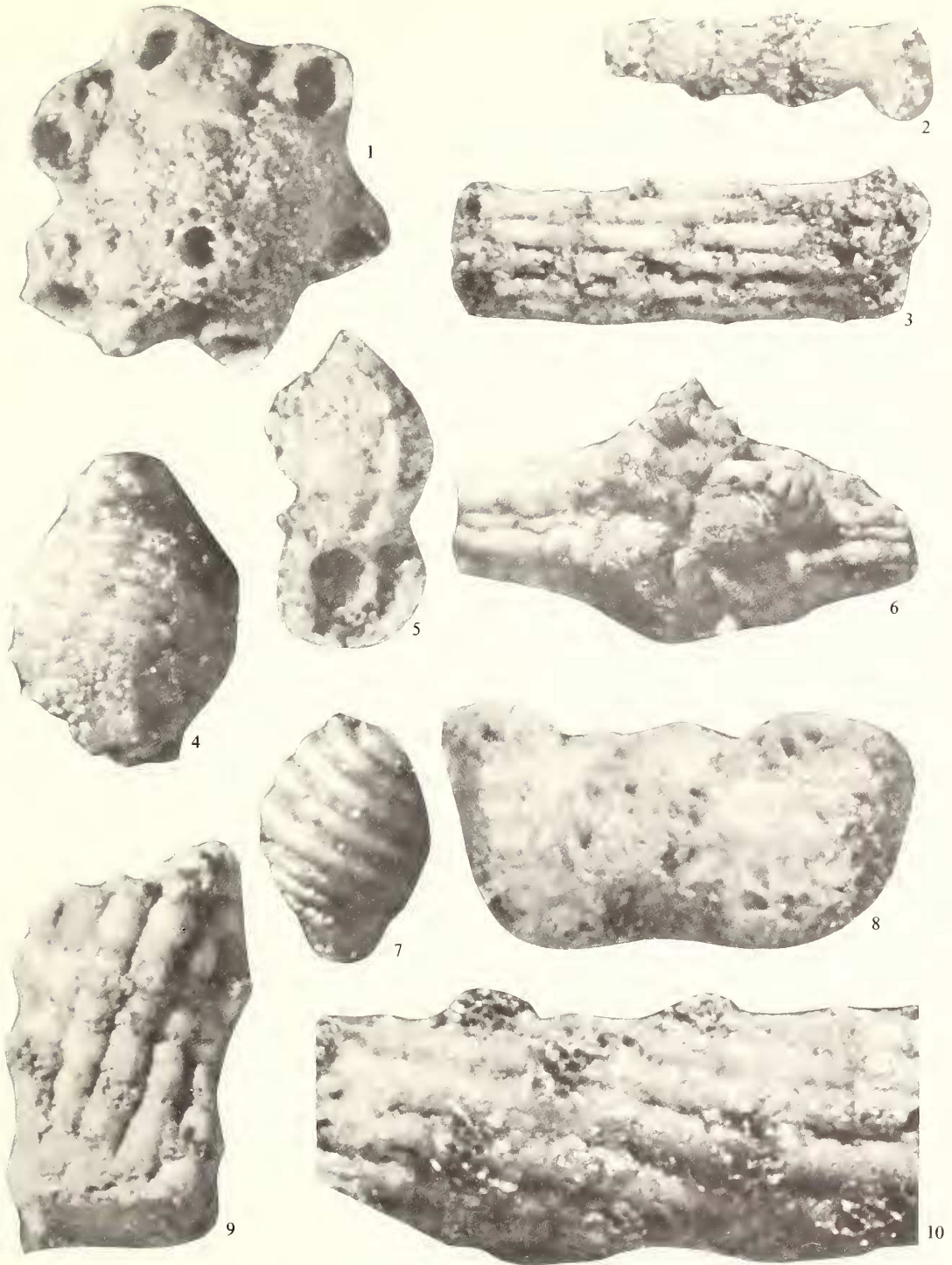
The leaves are represented by broken stumps on the nodes and by leaf fragments which are strongly curved. Some of these fragments evidently come from wider stumps than any of those seen on nodes. A large leaf had a central cell 380 μm wide and with the crust of spines reached 650 μm but most are much narrower. Leaves have nodes at intervals of 0·3–0·85 mm. Each node has a circle of six 'head' cells and from each of these 6–9 spine cells radiate and sometimes there are smaller cells as well. A few leaves have a regular round or oval hole at each node, considered to be the uncalcified base of an antheridium. One specimen bears on a node a stump considered to be the base of the utricle cells of an oogonium and another has a stump thought to be an oogonial stalk. Only one complete oogonium has been seen attached to a node and this one is abnormal being of very small size. Thus the reproductive leaves though less well known agree with those of the other species in bearing a single antheridium or a single oogonium at each fertile node.

Oogonium. Over 100 detached oogonia were studied. The most perfect are 600–700 μm long but many have lost their apices, and the width (with utricle) is 370–500 μm, most being about 450 μm. There is no obvious correlation between length and breadth. Usually something of the utricle is seen round the base of the oogonium, but sometimes nothing at all and at its best it extends to two-thirds of the length. Of course, this only refers to the calcified parts of the utricle cells, we do not know about any original uncalcified parts. At the base of an oogonium with a well-developed utricle the 6–8 utricle cells leave a gap which was presumably next to the leaf. The oogonial wall beyond the utricle usually shows flattened, almost square, tubercles situated along the mid-line of the spiral cells. As they are regularly spaced they make a pattern often of almost longitudinal files.

Gyrogonite. Only five isolated gyrogonites were seen but when oogonia were cleared by mounting in Canada balsam they were often seen plainly as opaque bodies. A few contain a collapsed brown membrane, the organic inner wall of the oogonium. The lateral face is crossed by 6, 7, or 8 ridges of spiral cells.

Comparison. The material forms a suite of organs, fragments of internodes, nodes, sterile leaves, antheridial leaves, oogonial leaves, and oogonia with more or less developed utricles and isolated gyrogonites. These were attributed to a single species after considering the possibility that there might be more than one. This species agrees fully in essentials with *Clavator reidi*, the type and best-known species of the genus. Harris (1939) described three species of *Clavator*, *C. reidi*, *C. grovesi*, each with a full suite of organs, and *C. bradleyi*, oogonia only. The stems and leaves of *C. westi* are easily distinguished from those of *C. reidi* and *C. grovesi* by their generally smaller size and much feebler development of spine cells, but there are small and perhaps poorly calcified specimens of the other two which look like *C. westi*. The main distinction is in the oogonia.

TABLE 1. A comparison of the Oogonia and Gyrogonites of *Clavator bradleyi* and *C. westi*.

The average dimensions of the oogonia of four species of *Clavator* are as follows:

C. reidi	700 μm long × 450 μm broad
C. grovesi	650 μm long × 450 μm broad
C. bradleyi	550 μm long × 360 μm broad
C. westi	600 μm long × 450 μm broad

	C. bradleyi (Correct to ±10 μm after Harris)	*C. westi* (Correct to ±15 μm)
Gyrogonites, perfect specimens with intact beaks	Lengths 430 μm, 450 μm, 470 μm, 480 μm	Lengths 520 μm, 535 μm, 535 μm, 565 μm, 565 μm
	Thirty-one specimens without apical beaks: Length typically 360 μm, extremes 270 μm and 470 μm	The above five specimens excluding apical beaks from 445 μm to 520 μm
	Breadth about 280 μm, extremes 250 μm and 360 μm	Breadth about 385 μm, extremes 375 μm and 435 μm
Oogonia	Typically 550 μm long × 360 μm broad	Typically 600 μm long × 450 μm broad

The average sizes do not differ much (see Table 1) but there are considerable differences in the utricles: the flat sides of *C. grovesi* distinguishes it at once and so does the usually strong development of *C. reidi*. *C. bradleyi* and *C. westi* are the most similar and the possibility was considered that they might be the same, but the differences in gyrogonite size are considerable. The selection of good specimens may have caused the apparent differences, though this is unlikely. It will be seen that *C. westi* is usually 50 or 100 μm longer and broader.

Species of other regions. Clavator pecki Mädler 1952 from the NW. German Kimmeridgian differs in its longitudinal, and highly calcified utricle cells. Its gyrogonite is 600–770 μm long, 370–630 μm broad, and the lateral view is crossed by 11–13 spiral cell ridges. The internode is highly calcified and doubly corticated, the cortical cells being remarkably oblique. It is thus very different in all its known parts from *C. westi*.

Carozzi (1948) described a series of gyrogonites from the Purbeck of Switzerland which he was able to identify with *C. reidi*, *C. grovesi*, and *C. bradleyi*. The specimens were studied in rock sections and thus however reliable their identifications may be, they are in a very different form from the present specimens and do not much assist their determination. Nodes and internodes agreeing with those of *C. reidi* are associated with the fructifications.

Clavator harrisi Peck, 1941 from the Lower Cretaceous of Western U.S.A. is known from a series of utricles, gyrogonites, and stem fragments. The oogonium is given as 700 μm $\times$ 570 μm; the utricle is usually very well developed (rarely feeble or absent) and usually bilaterally symmetrical rather as in *C. grovesi*. The associated nodes and internodes are very strongly calcified. This species then is very different from *C. westi*.

THE LAND PLANTS (C. E. B. AND S. C. B.)

The species described are the first land plants described since *Cycadeoidea gigantea* Seward, 1897 from the British Purbeck. The material examined was collected by Mr. West and by Professor Sylvester-Bradley from the Charophyte Chert (Bed 18). The plant remains were first noticed by Mrs. Valerie Sizer while treating the material at the University of Leicester.

The specimens studied are thought to have been first calcified and then secondarily silicified. They were extracted from the partly silicified rock with hydrochloric acid. There is an abundance of wood of conifer type, both from small twigs and fragments of larger branches. Unfortunately fine details of pitting were not preserved in the specimens we examined. Some bits of fusainized wood were also present and these are black but all other specimens have lost their original organic material. The seeds and other organs are rare, there were fewer than one per kilogram. Besides the seeds figured and described there are a good many less characterized specimens which are omitted and also obscure bodies of uncertain nature. Since some of the species described are only represented by one or two specimens it seems likely that search of further material would add considerably to the flora.

The fossils are uncompressed and white in colour except for the fusain. Some of them were sectioned by grinding and for this purpose the specimens were enclosed in plaster of Paris hardened in 'Lakeside 700 cement'.

SYSTEMATIC DESCRIPTIONS

EQUISETALES

Genus EQUISETUM Linnaeus

Equisetum mobergii (Halle ex. Möller)

Plate 58, fig. 5; text-fig. 3, figs. 1-6

1908   *Equisetites mobergii* Möller & Halle, p. 26, pl. 4, figs. 29–37.
1913   *Equisetites mobergii* Möller & Halle, p. 21, pl. 2, figs. 21–23; pl. 3, figs. 1–8.

Material. British Museum V.44926–V.44929.

Description. The three small specimens figured, agree with Halle's species though they are preserved differently. The width of the internodes is 2–4 mm, which is slightly narrower than those of Möller and Halle. The tops of the leaf sheaths are damaged and the apices of the teeth are broken, but what remains looks similar to their pl. 3, figs. 5, 6, 7. The specimens show stomata as pits, both on the internode and on the leaf sheath; the pits are scattered and occur at a concentration of up to twenty per sq. mm. As the specimens are solid and uncompressed they show the contour of the leaf sheath segments. The leaf segment forms a raised and rounded ridge with no midrib but two slight furrows separating the middle half from the two lateral quarters. The stem internode shows epidermal cells in vertical rows.

One specimen is hollow and shows some of its structure, there are cortical cavities opposite the leaves, and there is a ring of nodal tubercles probably equalling the leaves in number. These features agree with those of modern *Equisetum* stems.

Remarks. Neither of the two isolated nodes (which are very different from one another) figured by Möller and Halle is like this material: one is far bigger, and the other shows radiating spokes. The identification of this material with the differently preserved originals of *E. mobergii* is inevitably uncertain but there is close general agreement. The age of *E. mobergii* may be rather similar, Upper Jurassic or possibly Wealden (Möller and Halle 1913, p. 41).

Very few Mesozoic species of *Equisetum* have stems as narrow as 2-4 mm. The following are, however, comparable in size:

E. naktongensis Tateiwa including var. *tenuicaulis* see Oishi 1940, p. 189; the internodes differ in having longitudinal ribs.

E. ushimarensis (Yokoyama) may be the rhizomes of the same plant.

E. sp. A. Harris 1961; the stomata differ from our specimens in being in longitudinal lines.

EXPLANATION OF PLATE 58

Figs. 1, 2, 17, 18. Lateral views of *Carpolithes westi*, ×6. 1, is the Type Specimen V.44914. 2, V.44915 is sectioned in text-fig. 4, fig. 10. 17, is V.44914. 18, is V.44916.

Figs. 3, 10, 11, 19. *Carpolithes rhabdotus*, ×6. 3, a lateral view of V.44921 has the hilum downwards. See also text-fig. 4, figs. 2, 3. 10, 11, 19, are of the Type Specimen V.44920.

Fig. 4. *Carpolithes acinus*, Type Specimen, V.44919, ×6.

Fig. 5. *Equisetum mobergii* V.44928, ×6. See also text-fig. 3, figs. 1–3, 5, 6.

Figs. 6, 7. *Carpolithites* sp. V.44925, ×6.

Figs. 8, 9. *Carpolithes gibbus*, Type Specimen, V.44924, ×6. Fig. 9 is the micropylar end.

Figs. 12, 13. *Carpolithes glans*, Type Specimen, V.44911, ×6. Fig. 13 is the micropylar end.
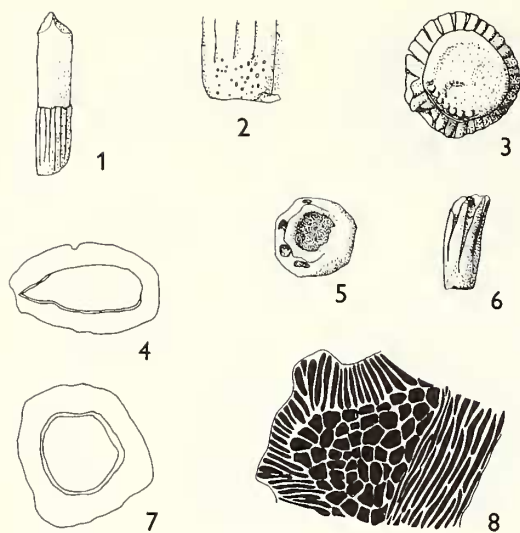
Figs. 14, 15. *Carpolithes rubeola*, Type Specimen, V.44908, ×6. Fig. 15 is the micropylar end.

Fig. 16. *Carpolithes cocos*, Type Specimen, V.44922, ×6. Micropyle is on the left.

Fig. 20. *Brachyphyllum* sp. V.44933, ×6.

Figs. 21, 22. *Araucarites sizerae*, ×6. 21, fragment A is the Type Specimen V.44931. 22, fragment B, V.44932 is the origin of the isolated seed V.44930 in text-fig. 4, figs. 4, 7, 8.

PLATE 58
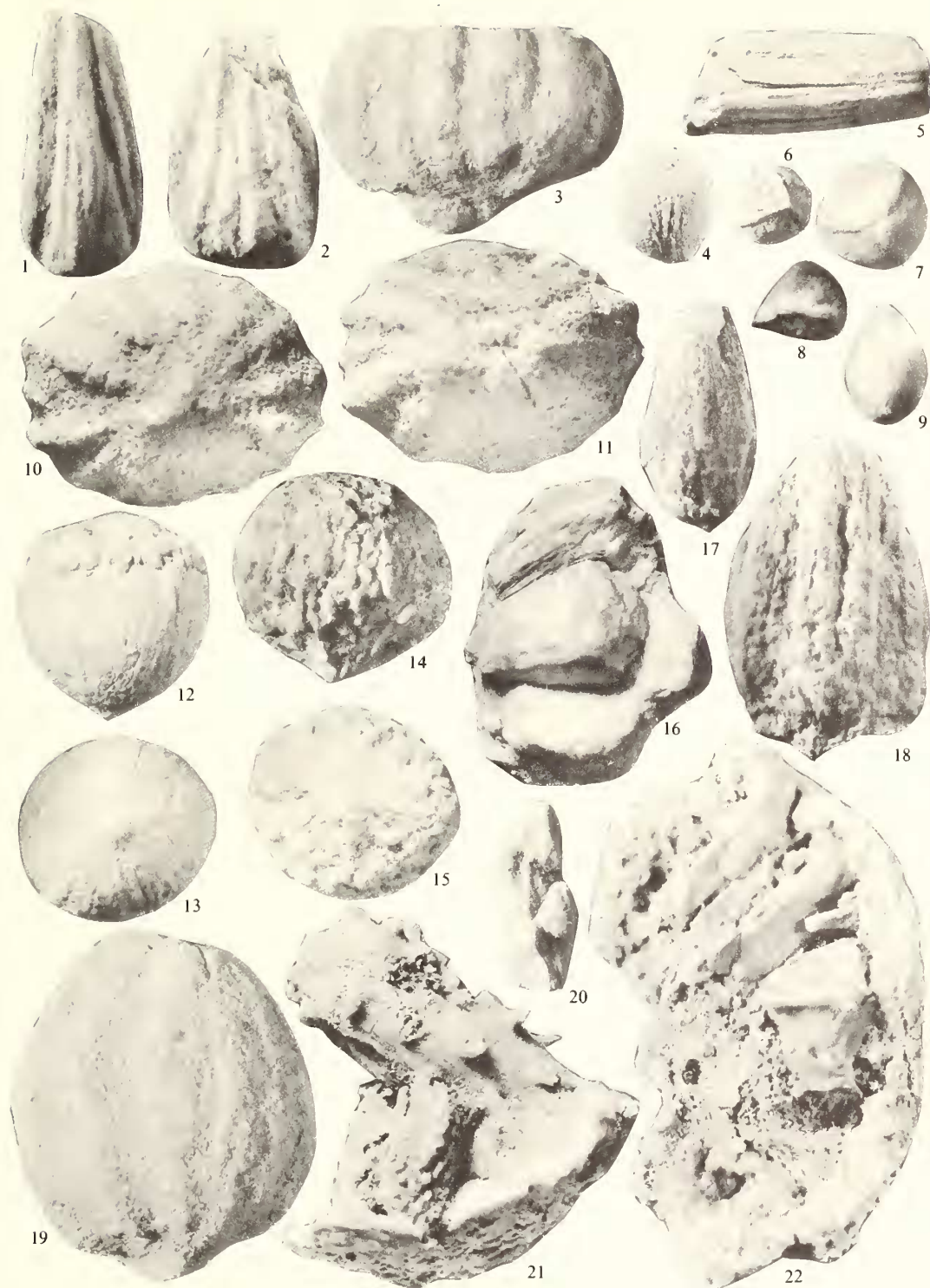
TEXT-FIG. 3. Figs. 1, 2, 3, 5, and 6. *Equisetum mobergii* (Halle). 1, leaf sheath and part of internode, V.44927, ×8. 2, lower-left corner of V.44927 to show stomata, ×40. 3, end view of leaf sheath, just above nodal level, V.44926, ×8. 5, end view just above nodal level, V.44928, ×29. 6, lateral view of V.44928, ×8. Figs. 4, 7, 8. *Carpolithes rubeola*. 4, longitudinal section, V.44906, ×18. 7, transverse section, V.44907, ×18. 8, L.S. integument, V.44906, ×140.

E. renaulti Raciborski 1894, p. 231; the leaf teeth are shown as having midribs and a stem of comparable size has fewer leaf teeth than ours.

E. gracilis (Nathorst) see Halle 1908, p. 15, has fewer leaves and probably a shorter sheath.

E. quindecimdentata Menendez 1958, p. 6, has rather wider stems with distinct ribs.

Cf. *E. bunburyanus* of Salfeld 1909, p. 7, looks fairly similar but there is rather little information. The leaf teeth perhaps end more abruptly.

CONIFERALES

Brachyphyllum sp.

Plate 58, fig. 20

One small specimen was found, its preservation is poor but examination of the back shows convincingly that the leaves are borne spirally. As the photograph shows the leaves are longitudinally ridged. Between the ridges there are some small and irregular pits (not visible in the photograph) which might represent stomata but no cellular details can be seen. There seems to be no median keel along the leaf, nor median resin body as in some species. Identification of such a twig is difficult but it is noteworthy that similar twigs occur in the Corallian of France (Saporta 1889), in particular *Brachyphyllum jauberti*, *B. moreauanum*, and *B. gracile*, though other specimens of these species are much thicker.

Unclassified seeds

The name *Carpolithes* Schlotheim is used in preference to any of the more recently proposed names. Although these seeds are partly petrified they yield far less information than the well-known Palaeozoic petrified seeds and are not comparable with them. Some Mesozoic seeds have been described by Chandler (1966) from America.

Carpolithes rubeola sp. nov.

Plate 58, figs. 14, 15; text-fig. 3, figs. 4, 7, 8

Derivation of name. From Rubeola, meaning measles, suggested by the lumpy surface.

Diagnosis. Seed orthotropous, stone broadly oval, rounded in section, apex abtusely pointed, base rounded: length 6 mm, width (major axis) 6 mm, depth (minor axis) 5 mm. Surface of stone shows both ridges and lumps. Ridges indefinite in number and unequal in size but running from above the base up to the apex. Three of the ridges stronger than others but not inclined at 120° to one another. Lumps often conspicuous but of very varied size, somewhat elongated but rounded near base of seed. Hilum rounded, indefinite, hilum end rough but much less coarsely rough than sides of seed. Stony layer of integument about 0·7 mm thick composed of three layers of stone cells. Outer layer palisade-like, forming the greater part of the lumps on the seed surface; middle layer of isodiametric cells which form a narrow core in the surface lumps; cells isodiametric both in transverse and longitudinal sections. Inner layer thin, even, composed of narrow elongated cells. Layer regarded as nucellus thin, forming a point near seed apex, closely adherent to integument.

Holotype. British Museum V.44908.

Remarks. The pointed end of the seed which contains the pointed end of the nucellus is regarded as micropylar. No tissues remain inside the nucellus.

Carpolithes glans sp. nov.

Plate 58, figs. 12, 13; text-fig. 4, fig. 5

Derivation of name. From the Latin *glans* meaning 'acorn'.

Diagnosis. Seed rounded in section, 5 mm long, 4 mm wide. Apex protruding as a short micropylar point. Base flattened with raised circular ridge 1 mm tall separated from rest of seed by a groove. Surface rather obscurely marked with longitudinal grooves, length varied, some extending from basal ridge to near micropylar point, others dying away. Grooves approx. 0·25 mm apart, becoming more faint towards apex. Surface

TEXT-FIG. 4. Fig. 1. *Carpolithes acinus.* Longitudinal section, V.44918, × 15. Figs. 2, 3. *Carpolithes rhabdotus*, V.44921; (see also Pl. 57, fig. 3). 2, longitudinal section of hilum end, × 12. 3, transverse section, × 10. Figs. 4, 7, 8. *Auracarites sizerae*, cone-scale bearing seed, V.44930 broken from V.44932, all × 10. 4, from above, 7, from below, × 10. 8, lateral view, × 10. Fig. 5. *Carpolithes glans.* Longitudinal section, V.44910, × 10. Figs. 6, 10. *Carpolithes westi*, × 10. 6, transverse section, V.44912. 10, longitudinal section, V.44915. Figs. 9, 11. *Carpolithes gibbus*, V.44923. 9, longitudinal section, × 18. 11, two thin outer layers of integument, × 180.
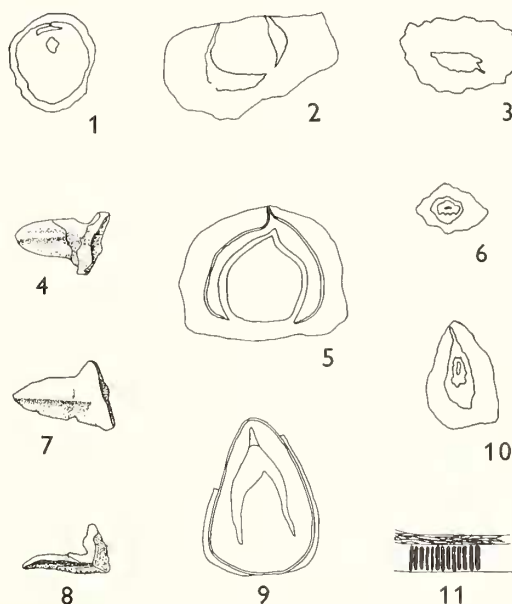
of basal ridge covered with irregular lumps, flattened area within this 3·5 mm across. Integument 0·7 mm thick; composed of four layers of cells; the cells of the outer one palisade-like; the cells of the inner layers of approximately isodiametric cells.

Holotype. British Museum V.44911.

Remarks. *C. glans* is represented by two specimens both photographed. One of these was sectioned. *C. glans* resembles *C. rubeola* in size and general shape; integument of *C. glans* is also quite similar except that *C. glans* has four layers of cells and *C. rubeola* has three. The surface of *C. glans* is faintly ridged whereas *C. rubeola* is lumpy and *C. glans* has a wider base.

Carpolithes rhabdotus sp. nov.

Plate 58, figs. 3, 10, 11, 19; text-fig. 4, figs. 2, 3

Derivation of name. From the Greek *rhabdotus* meaning 'fluted'.

Diagnosis. Seed ovoid, slightly flattened, tapering towards apex, basal part flattened but region of hilum raised. Length 9 mm, width in major axis 7 mm, in minor axis 5 mm, surface covered with prominent longitudinal ridges converging towards both ends but ending about 2 mm from base and about 1 mm from the apex. Ridges 12–16 in number, some of them less marked than others. Ridges about 0·5 mm high, edge rounded and furrow rounded. Basal end forming a broad cone, 2–3 mm wide. Micropylar region nearly round, about 1·5 mm wide, consisting of a ring-shaped depression round a central raised area. Stone of integument 1·5–1 mm thick (measured to tip of rib) composed of large isodiametric cells 0·88 mm in diameter, walls 0·01 mm thick. Cavity inside stone showing collapsed membranes about 3 mm × 1 mm.

Holotype. British Museum V.44920.

Description. *C. rhabdotus* is represented by two specimens both photographed, the one which had been broken before study was sectioned. This gave evidence that the micropyle is at the narrower end. The integument was separated from the inner tissue, perhaps the nucellus, by a space at the lower end.

Remarks. Saporta (1875), p. 244 described and figured a similar seed from the Oxfordian of France as *Cycadeospermum schlumbergeri.* It is, however, about three times larger than these seeds and it differs also in not being flattened around the hilum.

Carpolithes cocos sp. nov.

Plate 58, fig. 16

Derivation of name. From the seed's resemblance to a coconut in its husk.

Diagnosis. Seed with two coats. Outer coat fibrous, irregular in shape 1–2·5 mm thick composed largely of longitudinal fibres, base more or less rounded with broad hilum (apex missing). Inner coat a stone 4 mm long forming a three-sided pyramid with a rather flattened base 2·5 mm across. Surface of stone with faint, fine longitudinal striations.

Holotype. British Museum V.44922.

Description. The unique specimen had been broken before it was studied and no sections were attempted. The region of the micropyle had been damaged. The outer coat had here been broken away completely and the stone itself seems to have been slightly damaged. The three flat sides instead of meeting leave a small circular area 0·5 mm wide. This area looks as though it originally had a central canal.

Carpolithes gibbus sp. nov.

Plate 58, figs. 8, 9; text-fig. 4, figs. 9–11

Derivation of name. From the Latin *gibbus* meaning a 'hump back'.

Diagnosis. Seed 3 mm long, 1·5 mm wide (major axis), 1 mm wide (minor axis); one surface markedly convex, slightly keeled, the other slightly concave; hilum end rounded and micropylar end pointed. Surface smooth.

Integument of three layers, outer narrow 0·2 mm wide of palisade-like cells, middle 0·08 mm thick and fibrous, inner much wider, varying between 0·3–0·6 mm and showing no visible cells. Embryo sac 1·9 mm long, 1·5 mm wide at base, tapering to a point. Nucellus represented by nucellar plug 0·5 mm long at narrow end of seed.

Holotype. British Museum V.44924.

Description. *C. gibbus* is represented by two specimens one of which was sectioned. The nucellar plug was in the apex of the seed at the anterior end of the space left by the shrinkage of the embryo sac. The nucellar plug appears to fill the micropyle.

Carpolithes acinus sp. nov.

Plate 58, fig. 4; text-fig. 4, fig. 1

Derivation of name. From the Latin *acinus* meaning a 'pip'.

Diagnosis. Seed oval, flattened, 3 mm long, 2 mm wide in major axis and 0·4 mm in minor axis. One surface flat, the other convex. Micropyle forming a projection at the broader end, hilum flat. Surface of seed showing fine longitudinal striations. Integument about 0·3 mm thick enclosing nucellus.

Holotype. British Museum V.44919.

Description. *C. acinus* is represented by two specimens, one photographed and the other sectioned. In the nucellus at the micropylar end was a structure which may have been the pollen chamber, and a small round body which was possibly the embryo [text-fig. 4, fig. 1].

Carpolithes sp. indet.

Plate 58, figs. 6, 7

Material. British Museum V.44925.

This species is represented by two specimens, both with one end missing so both ends of the seed may not have been seen. In one specimen the three ridges meet to form a point, but in the corresponding position on the larger specimen there is a small depression, which may mark the hilum end. The smaller specimen is about 2 mm long and 1·5 mm across the widest part, and the larger is about 4 mm × 3 mm. Both show some structure of the stone where broken. It is about 0·3 mm thick and made up of two layers. The outer layer consists of radiating elongated cells about 0·1 mm × 0·02 mm, and the inner layer is fibrous. The cells are longitudinally arranged and about 0·01 mm wide.

Carpolithes westi sp. nov.

Plate 58, figs. 1, 2, 17, 18; text-fig. 4, figs. 6, 10

Derivation of name. After Mr. I. M. West.

Diagnosis. Seed flattened, wedge-shaped typically 5 mm long, 3 mm wide at basal end, in major transverse axis, 2 mm thick in minor transverse axis.

Flat surface on one side marked with about four longitudinal ridges; other side with a thickened median longitudinal region about 2 mm wide. Surface rather obscurely fibrous. Pointed end sometimes showing

a micropyle. Wall of stone of seed approximately 1 mm thick with micropylar canal 1 mm in length, composed of small stone cells, somewhat elongated in a radial direction. Nucellus pointed, 4 mm long, 1·5 mm in major and 0·5 mm in minor transverse axis.

Holotype. British Museum V.44913.

Description. C. westi is represented by a number of specimens showing a range of size 4 mm–8 mm long and 2 mm–5 mm wide at broadest end (basal). Several seeds were sectioned and showed similar structure. In the one figured the inner body regarded as nucellus is a uniform whitish tissue and encloses a brown membrane marked with cells which may form the edge of the megaspore membrane cavity. Inside this is a tiny shrivelled body of unknown nature; but visible in a number of seeds.

Remarks. These seeds look like those figured by Seward 1904, pl. 12, fig. 6 as 'Araucarites' from the English Inferior Oolite and *Carpolithus Lindleyanus* by Phillips 1871, Diag. 32, fig. 1. *C. westi* might be the remains of an *Araucarites* seed, perhaps somewhat water-worn.

CONIFERALES, *ARAUCARIACEAE*

Araucarites sizerae sp. nov.

Plate 58, figs. 21, 22; text-fig. 4, figs. 4, 7, 8

Derivation of name. After Mrs. V. Sizer, who isolated the specimens.

Diagnosis. Cone presumed to be spherical, about 2 cm in diameter. Axis of uniform width, 3 mm in diameter for most of length, tapering at upper end. Cone scales in a spiral, parastichies possibly 3+5. Stalks of cone scales round in section, those at the lower end bent slightly downwards. Outer surface of scales rhomboidal 3–4 mm from corner to corner, with a low, rounded median boss 1–2 mm wide. Seeds embedded singly in cone scale with pointed end towards the axis; seed about 4 mm long (including cone scale boss), 3 mm at wider end, and 1 mm thick.

Holotype. British Museum V.44931.

Description. A. sizerae is represented by two fragments, both illustrated. In both, the solid tissue has been replaced by silica and the gaps between the scales are empty or filled with powdery matter. It is possible that both are parts of the same cone but this could not be proved. The size of the cone and the parastichies were estimated from the two fragments.

Fragment A, the Type—regarded as from the apex, shows the axis bearing cone-scale stalks and some complete cone scales. The outer surface shows some of the cone-scale outlines, though obscurely.

Fragment B—this has lost its cone axis. The outer surface is almost featureless and forms part of an apparently spherical body. The inner side shows cone scales and seeds and in one place pits where cone-scale stalks have been pulled out. A single cone scale with its seed was pulled off and is illustrated in text-fig. 4, figs. 4, 7, 8.

Remarks. This cone is similar to that of a modern Araucaria, though there are no long pointed extensions of scales projecting outside the cone. These may have been rubbed off. No ligule was seen but this is easily missed in such a fossil.

The possibility was considered that the isolated seed called *Carpolithes westi* might be the basal seed-bearing part of the cone scale of the present cone. This still remains a possibility, but it was decided not to make them one species, because they do differ. It may be that the cone fragments are immature while the isolated *C. westi* seeds are mature but there is no evidence of this.

The smallest of the isolated seeds included in *C. westi* is as large as the typical *A. sizerae* seed and most are considerably larger (6–7 mm long). Their shape is also different, they are less flattened.

Since *C. westi* seeds have probably been somewhat worn and smoothed whereas the seeds in the cone have been protected, the actual difference in size may be even greater. Most specimens of *C. westi* have about four longitudinal ridges in one surface and one very rounded ridge on the other; seeds from *A. sizerae*, however, have a smooth upper surface and one marked longitudinal ridge on the lower. As far as is known, recent Araucaria species have much larger cones, and this is also true of the fossil cones described under

the name of *Araucarites*. The least different are small specimens of *A. mirabilis* figured by Calder 1953 from Patagonia (Upper Cretaceous or younger). The exposed surface shows that the ends of the scales are broader than those of *A. sizerae* and they are arranged in more numerous parastichies.

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D. BARKER
Middlesex Polytechnic at Enfield
Queensway, Enfield EN3 4SF